

ANSI/ITSDF B56.5-2019
(Revision of ANSI/ITSDF B56.5-2012)



SAFETY STANDARD FOR DRIVERLESS, AUTOMATIC GUIDED INDUSTRIAL VEHICLES AND AUTOMATED FUNCTIONS OF MANNED INDUSTRIAL VEHICLES

AN AMERICAN NATIONAL STANDARD

INDUSTRIAL TRUCK STANDARDS DEVELOPMENT FOUNDATION

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FOREWORD

(This foreword is not part of ANSI/ITSDF B56.5-2019)

On September 8, 1972, the B56.5 Subcommittee started work on this standard at the direction of the B56 Committee and the Sponsor, The American Society of Mechanical Engineers (ASME). Following a number of work sessions and ballots within the Subcommittee and the B56 Standards Committee, it was submitted to ASME B56 Committee ballot, public review, and Secretariat approval. After obtaining such approval, the Standard was submitted to the American National Standards Institute, Inc. (ANSI). ANSI approval to issue the Standard as American National Standard B56.5 was granted on August 30, 1978.

On October 18, 1984, the B56.5 Subcommittee held a meeting to begin work on the revision of ANSI B56.5-1978. After a number of additional subcommittee meetings, the Subcommittee came to consensus agreement on a proposed revision. The proposed revision was submitted for B56 Committee ballot and public review. After consideration of comments received, the proposed revision was submitted to the Sponsor for its approval. After obtaining approval, the proposed revision was submitted to ANSI and was approved and designated as an American National Standard on May 17, 1988.

Subsequently, addenda to the 1988 edition were approved and published in 1989, 1990, 1991, and 1992. Proposed revisions for inclusion in the 1993 edition were approved by the B56 Committee and the Sponsor, and were submitted for public review. The 1993 edition, which incorporated the revisions contained in the four addenda to the 1988 edition plus those revisions approved for the 1993 edition, was approved and designated as an American National Standard by ANSI on August 30, 1993.

The 2004 edition incorporates changes made in the ASME B56.5a-1994 supplement, as well as additional revisions. It was approved for issuance as an American National Standard on February 23, 2004.

On September 1, 2005, management of the B56 Standards Committee and its Subcommittees was transferred from ASME to the Industrial Truck Standards Development Foundation. This Standard was reaffirmed by the B56 Standards Committee after references to ASME were changed to ITSDF.

The 2012 edition of B56.5 was approved by the American National Standards Institute on March 1, 2012.

ANSI/ITSDF B56.5-2019 was approved as a revision by the American National Standards Institute on August 6, 2019.

This Standard shall become effective 1 year after its respective Date of Issuance. Part III applies only to trucks manufactured after the effective date.

Safety codes and standards are intended to enhance public health and safety. Revisions result from committee consideration of factors such as technological advances, new data, and changing environmental and industry needs. Revisions do not imply that previous editions were inadequate.

ITSDF STANDARDS COMMITTEE ROSTER B56

Powered and Nonpowered Industrial Trucks

(The following is the roster of the Committee at the time of approval of this Standard.)

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SUBCOMMITTEE B56.5 – SAFETY STANDARD FOR GUIDED INDUSTRIAL VEHICLES AND AUTOMATED FUNCTIONS OF MANNED INDUSTRIAL VEHICLES

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Jörn Soukup, Jungheinrich
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Mitchell Weiss, Piaggio Fast Forward

ANSI/ITSDF B56.5-2019 SUMMARY OF CHANGES

Following approval by the ITSDF B56 Committee and after public review, ANSI/ITSDF B56.5-2019 was approved as a revision by ANSI on August 6, 2019. The revision consists of updating the wording and provisions of the scope, Part II for the user, Part III for the manufacturer, and the glossary of commonly used words and phrases. Changes are indicated by the margin note **(19)**.

POWERED AND NONPOWERED INDUSTRIAL TRUCKS

B56 SERIES INTRODUCTION

GENERAL

This Standard is one of a series that have been formulated with the Industrial Truck Standards Development Foundation as Sponsor in accordance with the Accredited Organization method, the procedures accredited by the American National Standards Institute, Inc., and the following scope:

Establishment of the safety requirements relating to the elements of design, operation, and maintenance; standardization relating to principal dimensions to facilitate interchangeability, test methods, and test procedures of powered and nonpowered industrial trucks (not including vehicles intended primarily for earth moving or over-the-road hauling); and maintenance of liaison with the International Organization for Standardization (ISO) in all matters pertaining to powered and nonpowered industrial trucks.

One purpose of the Standard is to serve as a guide to governmental authorities having jurisdiction over subjects within the scope of the Standard. It is expected, however, that the Standard will find a major application in industry, serving as a guide to manufacturers, purchasers, and users of the equipment.

For convenience, Standards of Powered and Nonpowered Industrial Trucks have been divided into separate volumes:

Safety Standards

- B56.1 Low Lift and High Lift Trucks
- B56.5 Guided Industrial Vehicles and Automated Functions of Manned Industrial Vehicles
- B56.6 Rough Terrain Forklift Trucks
- B56.8 Personnel and Burden Carriers
- B56.9 Operator Controlled Industrial Tow Tractors
- B56.10 Manually Propelled High Lift Industrial Trucks
- B56.14 Safety Standard for Vehicle Mounted Trucks

Standardization Standards

- B56.11.1 Double Race or Bi-Level Swivel and Rigid Industrial Casters
- B56.11.4 Hook-Type Forks and Fork Carriers for Powered Industrial Forklift Trucks
- B56.11.5 Measurement of Sound Emitted by Low Lift, High Lift, and Rough Terrain Powered Industrial Trucks
- B56.11.6 Evaluation of Visibility from Powered Industrial Trucks
- B56.11.7 Liquefied Petroleum Gas (LPG) Fuel Cylinders (Horizontal or Vertical) Mounting – Liquid Withdrawal – for Powered Industrial Trucks
- B56.11.8 Safety Standard for Seat Belt (Lap-Type) Anchorage Systems for Powered Industrial Trucks

Safety standards that were previously listed as B56 volumes but now have different identification due to a change in standards development assignments are as follows:

- NFPA 505 Fire Safety Standard for Powered Industrial Trucks – Type Designations, Areas of Use, Maintenance and Operation (formerly B56.2)
- UL 583 Standard for Safety for Electric-Battery-Powered Industrial Trucks (formerly B56.3)
- UL 558 Standard for Safety for Internal Combustion Engine-Powered Industrial Trucks (formerly B56.4)

If adopted for governmental use, the references to other national codes and standards in the specific volumes may be changed to refer to the corresponding governmental regulations.

The use of powered and nonpowered industrial trucks is subject to certain hazards that cannot be completely eliminated by mechanical means, but the risks can be minimized by the exercise of intelligence, care, and common sense. It is therefore essential to have competent and careful operators, physically and mentally fit, and thoroughly trained in the safe operation of the equipment and the handling of the loads. Serious hazards are overloading, instability of the load, obstruction to the free passage of the load, collision with objects or pedestrians, poor maintenance, and use of equipment for a purpose for which it was not intended or designed.

Suggestions for improvement of these Standards, especially those based on actual experience in their application, shall be submitted to the Secretary of the B56 Committee, ITSDF, 1750 K Street NW, Suite 460, Washington DC 20006.

Comments shall be written in accordance with the following format:

- (a) specify paragraph designation of the pertinent volume;
- (b) indicate suggested change (addition, deletion, revision, etc.);
- (c) briefly state reason and/or evidence for suggested change;
- (d) submit suggested changes to more than one paragraph in the order in which they appear in the volume.

The appropriate B56 Subcommittee will consider each suggested revision at its first meeting after receipt of the suggested revision(s).

SAFETY STANDARD FOR DRIVERLESS, AUTOMATIC GUIDED INDUSTRIAL VEHICLES AND AUTOMATED FUNCTIONS OF MANNED INDUSTRIAL VEHICLES

Part I Introduction

1 SCOPE

This Standard defines the safety requirements relating to the elements of design, operation, and maintenance of powered, not mechanically restrained, unmanned automatic guided industrial vehicles and the system of which the vehicles are a part. It also applies to vehicles originally designed to operate exclusively in a manned mode but which are subsequently modified to operate in an unmanned, automatic mode, or in a semiautomatic, manual, or maintenance mode.

- (19) This Standard applies to automatic guided industrial vehicles in automatic mode of operation in non-restricted areas. Portions of this Standard, when designated, also apply to semiautomatic, manual, and maintenance modes and restricted areas of vehicle operation. It is recognized that restricted areas may exist, and require the user and system supplier to determine appropriate safeguard measures. This standard does not apply to vehicles operating in closed areas where personnel are not allowed and appropriate interlocking systems, safeguards, and procedures are in place.

Portions of this Standard, when designated, also apply to automated functions of manned vehicles.

This Standard does not apply to passenger-carrying vehicles.

2 PURPOSE

The purpose of this Standard is to promote safety through the design, construction, application, operation, and maintenance of unmanned guided industrial vehicles and automated functions of manned industrial vehicles.

This Standard may be used as a guide by governmental authorities desiring to formulate safety rules and regulations. The Standard is also intended for voluntary use by others associated with manufacturing or use of unmanned guided industrial vehicles and automated functions of manned industrial vehicles.

3 INTERPRETATION

3.1 Mandatory and Advisory Rules

To carry out the provisions of this Standard, the word *shall* is to be understood as mandatory and the word *should* as recommended.

3.2 Classification of Approved Automatic Guided Industrial Vehicles

The word *approved* means the classification or listing of automatic guided industrial vehicles as to fire, explosion, and electric shock hazard by a nationally recognized testing laboratory.

3.3 Requests for Interpretation

The B56 Committee will render an interpretation of any requirement of this Standard. Interpretations will be rendered only in response to a written request sent to the Secretary of the B56 Committee, ITSDF. The request for interpretation shall be in the following format.

Subject: Cite the applicable paragraph number(s) and provide a concise description.
Edition: Cite the applicable edition of the pertinent standard for which the interpretation is being requested.

Question: Phrase the question as a request for an interpretation of a specific requirement suitable for general understanding and use, not as a request for approval of a proprietary design or situation. The inquirer may also include any plans or drawings, which are necessary to explain the question; however, they should not contain proprietary names or information.

ITSDF procedures provide for reconsideration of any interpretation when or if additional information, which might affect an interpretation is available. Further, persons aggrieved by an interpretation may appeal to the cognizant ITSDF Committee or Subcommittee. ITSDF does not “approve,” “certify,” “rate,” or “endorse” any item, construction, proprietary device, or activity.

3.4 Metric Conversions

The values stated in metric units are to be regarded as the standard. U.S. Customary units are maintained in the Users Section (in parenthesis) as information for those not familiar with metric units. The conversion to U.S. Customary is a direct (hard) conversion from SI units.

Part II For the User

4 GENERAL SAFETY PRACTICES

4.1 Introduction

4.1.1 Before putting an automatic guided industrial vehicle system into service, the user shall be responsible for all factors affecting the operation and maintenance, as referenced in Part II of this Standard.

4.1.2 Automatic guided industrial vehicles can cause injury or damage if improperly used or maintained and if the potential risks specified in user training associated with hazard zones and restricted areas are not respected by persons within or adjacent to these areas.

4.1.3 Part II contains safety standards applicable to vehicle operations. Unusual operating conditions may require additional safety precautions and/or safeguard measures. Automatic guided industrial vehicles which can be operated by manual control may have restricted operational characteristics.

4.1.4 Part IV contains safety standards applicable to automated functions of manned industrial vehicles.

4.2 Modifications, Nameplates, Markings, and Capacity

4.2.1 Except as provided in para. 4.2.2, no modifications or alterations to an automatic guided industrial vehicle that may affect the capacity, stability, or safe operation of the vehicle shall be made without the prior written approval of the system supplier or its successor thereof. When the system supplier or its successor approves a modification or alteration, appropriate changes shall be made to capacity plates, decals, tags, and operation and maintenance manuals.

4.2.2 In the event that the system supplier is no longer in business and there is no successor to the business, the user may arrange for a modification or alteration to an automatic guided industrial vehicle provided however, the user

(a) arranges for modification or alteration to be designed, tested, and implemented by an engineer(s) expert in Automatic Guided Industrial Vehicles and their safety

(b) maintains a permanent record of the design test(s), and implementation of the modification or alteration

(c) makes appropriate changes to the capacity plate(s), decals, tags, and operation and maintenance manuals

(d) affixes a permanent and readily visible label on the truck stating the manner in which the truck has been modified or altered together with the date of the modification or alteration, and the name of the organization that accomplished the tasks

4.2.3 The user shall see that all nameplates and caution and instruction markings are in place and legible.

4.2.4 When utilizing lifting equipment such as elevators, cranes, ship hoisting gear, etc., to relocate a guided industrial vehicle, the user shall assure that the capacity of the hoisting equipment being used is not exceeded.

4.2.5 The user shall consider the changes in load(s), load position(s), or dimension(s), coupling types(s), or position(s), and floor surface condition(s) or battery weights may affect rated capacities and safe operation. Only stable or safely arranged loads shall be handled.

4.2.6 The user shall be responsible for the load stability and retention. When deemed necessary by the user, verification shall be required.

4.2.7 Some users may decide to establish, for their own use, stability requirements that will vary from those in para. 8.7.4. However, the requirements in para. 8.7.4 should serve as a guide for the user, working with the manufacturer, in establishing its own more stringent requirements.

4.3 Stopping Distance

4.3.1 The determination of the vehicle's stopping distance (whether used as a load carrying vehicle or a tow vehicle) depends on many factors, such as other vehicle and pedestrian traffic, clearances, condition of the floor, and the stability and retention requirements of load(s). The prime consideration is that the braking system in conjunction with the object detection system and the response time of the safety control system shall cause the vehicle to stop prior to impact between the vehicle structure and other mounted equipment, including its intended load, and an obstruction being sensed in advance of the moving vehicle in the main direction of travel. (see Sections III, para. 8.7.1 (c) (2) and para 8.11).

(19) **4.3.2** Should an object suddenly appear in the path of the vehicle between the leading edge of the sensing field and the vehicle (i.e. an object falling from overhead or a pedestrian stepping into the path of a vehicle at the last instant), the vehicle shall initiate braking in accordance with brake system (see para. 8.8.1), but may not be expected to stop in time to prevent contact with object.

(19) **4.3.3** Caution should be exercised with changed environments. Changes in weather, surface conditions, or applications may affect the vehicle stopping distance; speeds, loads, brake settings, and/or operation should be adjusted accordingly.

4.4 Sensors

If a load exceeds the width and/or length of the vehicle, the user should require that sensors in the direction of travel covering the maximum moving width and/or length be provided to prevent contact between the load and any obstruction.

4.5 Charging and Changing of Batteries

The user shall make battery changing and charging provisions in accordance with ANSI/NFPA 505. Battery types and charging systems supplied or specified by the vehicle manufacturer (e.g., opportunity charging) but not referenced in ANSI/NFPA 505 shall be safely operated and charged per the instructions supplied by the vehicle manufacturer.

4.6 Hazardous Locations

4.6.1 Other than hazard zones as specified in PART III, para. 8.11.2, it shall be the responsibility of the user to determine the hazard classification of any particular atmosphere or location according to ANSI/NFPA 505.

4.6.2 Vehicles operated in hazardous locations as determined by ANSI/NFPA 505 shall be of the type required by ANSI/NFPA 505 and shall be so identified.

4.7 Aisles and Doors

4.7.1 Restricted areas of vehicle operation require identification and/or marking.

4.7.2 In non-restricted areas, the floor space boundary required for the vehicle and its intended load and/or train shall be clearly marked, including the clearance necessary for turns and maneuvering.

4.7.3 Doors subject to automatic actuation and blind corners shall have suitable audible and/or visual alarms to anticipate the approach of the automatic vehicle or door actuation. Passive devices such as mirrors are recommended also.

- (19) **4.7.4** A minimum guidepath clearance (see glossary) of 0.5 m (19.7 inches) shall be maintained on both sides of the guidepath or on one side of the guidepath if the guidepath clearance on the other side is 0.1m (3.94 inches) or less to a continuous closed fixed structure (e.g. a wall). All other areas shall be considered hazard zones or restricted areas and be clearly marked by signs, stripes, lights, or other designations. (see Part III, para 8.11.2)

4.7.4.1 Hazard zones and/or restricted areas shall be designated as such by the user and system supplier during the design, installation, and start up phases, and it shall then be the responsibility of the user to cause these areas to be clearly marked by stripes, lights, or other designations. It is also the responsibility of the user to maintain system documentation with regard to new hazard zones and/or restricted areas that may be created by the user following system acceptance and to likewise cause these new areas to be clearly marked in a similar fashion.

4.7.4.2 All hazard zones or restricted areas shall be the subject of verifiable training of user personnel 1) conducted by the system supplier prior to the initial start up of operations; and 2) then by the user on an ongoing basis following system acceptance. (see para. 6.3 and Section III, para. 8.11.2.1.2)

4.7.5 Doors

(a) Automatic vehicle guide paths should not be routed through doorways frequented by personnel unless the opening is wide enough for personnel to remain outside the guidepath clearance aisle. Also, opening and closing of powered or non-powered doors shall be accomplished in a manner that alerts or restricts personnel near the doorway.

(b) In order to minimize the possibility of blocking the complete closing of a fire door, the vehicle will respond to a signal such as an input from a limit switch and/or heat sensor and stop prior to the fire door.

(c) System design should not have a normal stop location where a vehicle or its load would block a fire door closure.

4.8 Ambient Lighting

There are no ambient lighting requirements for automatic vehicle systems.

4.9 Safety Devices (Systems)

4.9.1 Vehicle

(a) *Warning Devices.* The user and system supplier should agree upon the time interval(s) for warning device actuation. See para. 8.9

(b) *Emergency Devices.* See para. 8.10.

(c) *Nonemergency Devices.* See para. 8.11.

(d) *Turn Signals.* These are not mandatory but should be made available by the manufacturer, if requested.

4.9.2 Facility. Signs, warning devices, and other safety devices should be used as required to alert and to protect the personnel from contact with the vehicle or items actuated by the vehicle. This includes equipment that is designed to interact with the vehicle system.

4.9.3 Safety Devices. Vehicle safety devices shall not be manually overridden in automatic or semiautomatic modes of operation.

4.10 Vehicle Emergency and Nonemergency Controls and Devices

Requirements in addition to those specified in para. 8.10 and 8.11 may be specified by the user, but shall not negate the provisions of para. 8.10.

5 INSTALLATION

5.1 General Guidelines

- (a) All hazardous locations shall be marked in accordance with ANSI/NFPA 505.

(b) Permanent aisles, roadways, and passageways shall be marked by the user as a warning to personnel of existing or impending automatic guided industrial vehicle traffic and to indicate that these vehicles have the right of way.

(c) Restricted areas shall be clearly marked.

(d) Central battery changing and charging facilities and procedures shall be in accordance with Section 5-3 of ANSI/NFPA 505.

(e) Vehicle nameplate ratings are based on level, dry surfaces having a minimum coefficient of friction with the driven and brake tire of 0.6. Other surface conditions may impact vehicle safety and require appropriate vehicle derating.

5.2 Operating Environment

5.2.1 Travel Surface. The surfaces over which the vehicle system operates shall be maintained to ensure that the traction required for travel, steering, and braking performance can be met under the environmental conditions which may be expected on that surface.

5.2.2 Physical Environment. The physical environment, including temperature, humidity, ambient weather (e.g., exposed dock), air quality (e.g., explosive particulates, and/or gaseous constituents) shall be a part of the vehicle design criteria. Changes to the environment shall be evaluated to verify there is not adverse effect on the vehicle's safety systems.

5.2.3 Radiated Emissions. Many types of devices may emit energy, such as electromagnetic, electrostatic, or optical, that could affect the operation of the vehicle system. Likewise, vehicle systems may emit energy that could affect other systems and/or personnel. Users should seek guidance from the system supplier if interference is suspected. The conditions acceptable for the vehicle system installation shall be defined by user and system supplier agreement.

6 OPERATION

6.1 User Responsibility

The user is responsible for the safe operation of the vehicle system.

6.2 Manual Functions

Only personnel trained in accordance with para. 6.3 shall manually operate an automatic guided industrial vehicle. Operators shall be qualified as to their ability to safely operate the equipment.

6.3 General Training

A training program for operators and other user personnel likely to be exposed to the system in operation, including visitors, shall include the system supplier's documented operating instructions and procedures and the user's local applicable requirements if any. The initial training shall be presented by the system supplier to all operators and other user personnel and not condensed or eliminated for those claiming previous experience. Oral, written, or operational performance tests and evaluations should be given during and at the completion of all training. Periodic, ongoing training or refresher training sessions shall then be conducted by the user for the benefit of existing users as well as for new user personnel and visitors. Refresher training sessions, which may be condensed versions of the initial training sessions, and periodic on-the-job evaluation, are as important as initial training, especially when new personnel are hired or otherwise introduced to the system following initial deployment.

For areas designated by the user and system supplier, or subsequently by the user, as hazard zones or restricted areas due to inadequate clearances, or the potential for inadequate clearances with no escape route, user personnel and any person likely to come into contact with the vehicle system shall be the subject of verifiable training concerning the risk and how to avoid risk.

6.4 User Personnel Responsibility

The user personnel shall abide by all applicable safety rules and practices.

6.5 General Instructions

Safety and operating instructions shall be provided to the operators and other user personnel as applicable, these include the following:

- (a) safeguarding of personnel
- (b) passenger riding restrictions
- (c) loading of vehicles and trailers
- (d) maintaining a safe distance from the edge of ramps, platforms, and other objects
- (e) use on trailer(s) or railcar(s)
- (f) using vehicles in hazardous locations
- (g) reporting of vehicle incidents
- (h) keeping vehicles clear of fire aisles, doors, access to stairways, and fire equipment
- (i) sequence of operation with interfacing equipment
- (j) use of braking system(s)

6.6 Manual Operation

6.6.1 Manual operation of fork-type guided industrial vehicles shall also comply with applicable sections of ANSI/ITSDF B56.1 not addressed in this Standard.

6.6.2 Manual operation of burden carrier-type guided industrial vehicles shall also comply with applicable sections of ANSI/ITSDF B56.8 not addressed in this Standard.

6.6.3 Manual operation of towing-type guided industrial vehicles shall also comply with applicable sections of ANSI/ITSDF B56.9 not addressed in this Standard.

6.6.4 Other type vehicles may require additional considerations.

7 MAINTENANCE

7.1 Warning

Vehicles may become hazardous if maintenance is neglected. Therefore, maintenance facilities, trained personnel, and procedures shall be provided.

7.2 Maintenance

Maintenance and inspection of all vehicle systems shall conform to the manufacturer's recommendations.

7.2.1 Preventive

- (a) All manufacturer's supplied plates, tags, and decals shall be maintained in legible condition.
- (b) All components, including object detection devices shall be inspected at regular intervals and maintained in accordance with the vehicle component manufacturer's or vehicle manufacturer's recommendations.
- (c) Vehicle systems shall be kept in clean condition to minimize fire hazards and facilitate detection of loose or defective parts.
- (d) Safety and warning systems shall be maintained in operational readiness.
- (e) The volume of audible warning devices as required in Section III, para. 8.9.2 shall be checked on a regular basis and the volume levels discussed and agreed upon between the user and the system supplier taking into consideration the ambient noise levels existing throughout the areas where vehicles will be operating.

7.2.2 Diagnosis and Repair

- (a) Only authorized personnel shall be permitted to maintain, repair, adjust, and inspect vehicle systems.

(b) Modifications and/or additions to hardware or software which affect rated capacity, safe operation, or any emergency control or device shall not be performed without the system supplier's verifiable approval. Where such authorization is granted, capacity, operation, and maintenance instruction plates, tags, or decals shall be changed accordingly.

(c) Care shall be taken to ensure that all replacement parts are interchangeable with the original parts and of a quality and performance at least equal to that provided in the original equipment.

7.2.3 Batteries and Chargers

The user shall maintain batteries and changing and charging systems in accordance with ANSI/NFPA 505. Battery types and charging systems supplied or specified by the vehicle manufacturer (e.g., opportunity charging) but not referenced in ANSI/NFPA 505 shall be maintained in accordance with instructions supplied by the vehicle manufacturer.

7.3 Maintenance Training

7.3.1 Only authorized persons shall be permitted to control or maintain a vehicle system.

7.3.2 Maintenance and support personnel of the system shall be trained by qualified persons. Training may include the following:

- (a) operations
- (b) electrical maintenance
- (c) mechanical/fluidic maintenance
- (d) systems level (where applicable)

7.3.3 It is the user's responsibility to follow all procedures for the operation and maintenance of equipment.

7.4 Documentation of Maintenance Activities

Records of maintenance activities performed should be kept.

Part III

For the System Supplier and Manufacturer

8 DESIGN AND CONSTRUCTION STANDARDS

8.1 Introduction

Part III contains safety standards for the design and construction of unmanned, automatic guided industrial vehicles and the system of which the vehicles are a part. Part IV contains safety standards applicable to automated functions of manned industrial vehicles.

As used herein, the term manufacturer refers to the original vehicle manufacturer (see glossary, manufacturer). The term system supplier refers to the entity with responsibility for the system design, the design requirements, the installation and integration of the vehicle(s) and the overall performance of the system and vehicle(s) according to the provisions of this standard (see glossary, system supplier). Although the manufacturer and system supplier may be one and the same entity, it is also common for the system supplier to be a third party entity separate from the manufacturer.

8.2 Rated Capacity of Towing Vehicles

8.2.1 Guided tow vehicles shall have an established maximum drawbar pull and normal rated drawbar pull. These ratings are based on level, dry surfaces having a minimum coefficient of friction with the driving and braking tire of 0.6. The battery weight and size used shall be within limits stated on the vehicle nameplate.

8.2.2 Maximum drawbar pull in pounds (Newtons) shall be defined by the manufacturer at the specified coupler height under the conditions of para. 8.2.1 When traveling at a minimum of 0.22 m/s and for a minimum of 30 sec.

8.2.3 Normal rated drawbar pull is the greatest continuous towing force in pounds (Newtons) which can be sustained under the conditions of para. 8.2.1 including rated speed or duty cycle.

8.2.4 If the vehicle has load-carrying capacity in addition to towing capabilities, load testing is also required. See para. 8.3.

8.2.5 Drawbar pull rating tests shall be performed as follows:

(a) *Test Conditions*

Course surface to be as defined in para. 8.2.1

(b) *Test Methods*

The test cycle is made up of the following

(1) one 61 m run with trailer load as per para. 8.2.2

(2) one 61 m run with trailer load as per para. 8.2.3

(3) vehicle shall accelerate to rated speed during each run and loads shall be cycled at least 6 times per hour

(4) continuous test until a stable temperature has been reached for a minimum of 1 hr on components

(5) In addition to the test in para. 8.2.5(b), alternate rated drawbar pull is the sustained towing force in pounds (Newtons) using special test conditions and test methods to suit the user's operation.

8.3 Rated Capacity of Load-Carrying Vehicles

8.3.1 Automatic guided industrial vehicles shall have an established load-carrying capacity. This rating is based on level, dry surfaces having a minimum coefficient of friction with the driving and braking tire of 0.6. The battery weight and size used shall be within limits stated on the vehicle nameplate.

8.3.2 If the vehicle has towing capacity in addition to load-carrying capabilities, towing testing is also required. See para. 8.2.

8.3.3 Load-carrying capacity tests shall be performed as follows:

(a) Test Conditions

- (1) as defined in para. 8.3.1
- (2) vehicle with rated load
- (3) unloaded vehicle

(b) Test Methods

The test cycle is made up of the following:

- (1) one 61 m run carrying full rated load
- (2) one 61 m run with no load condition
- (3) vehicle shall accelerate to rated speed during each run and loads shall be cycled at least 6 times per hour
- (4) continuous test until a stable temperature has been reached for minimum of 1 hr on components

8.4 Additional Automatic Guided Industrial Vehicle Requirements

8.4.1 Fork-type guided industrial vehicles shall also comply with applicable sections of ANSI/ITSDF B56.1 not addressed in this Standard.

8.4.2 Burden carrier-type guided industrial vehicles should also comply with applicable sections of ANSI/ITSDF B56.8 not addressed in this Standard.

8.4.3 Towing-type automatic guided industrial vehicles should also comply with applicable sections of ANSI/ITSDF B56.9 not addressed in this Standard.

8.4.4 Other type vehicles may require additional considerations.

8.5 Vehicle Nameplate and Marking

8.5.1 On every vehicle, the manufacturer shall install a durable, corrosion-resistant nameplate(s) legibly inscribed with the following:

- (a) vehicle model or vehicle serial number or both.
- (b) weight of unloaded vehicle without battery or fuel (empty weight).
- (c) designation of compliance with the mandatory requirements for Part III of this Standard.
- (d) indication of type if in conformance with or rated per ANSI/UL 583 or ANSI/UL 558.
- (e) maximum and normal or alternate rated drawbar pull for towing vehicles (see Section III, para. 8.2.5).
- (f) rated load (weight, envelope, and center of gravity) and lift height, if applicable.
- (g) identification of battery classification, if applicable, minimum and maximum weight and dimensions of battery(s), rated ampere-hour capacity, and nominal voltage.
- (h) for towing applications, the coupling height at which capacities were determined.
- (i) rated speed (speed of vehicle for purpose of rating).
- (j) if non battery-powered, identification of fuel requirements.
- (k) maximum grade capability at rated load.

8.5.2 The vehicle serial number shall be stamped on the frame of the vehicle.

8.6 Guidance

8.6.1 Deviation of travel from the intended path shall require an emergency stop unless otherwise dictated by the application and an assessment of the attendant risk.

8.6.2 Loss of guidance reference shall require an emergency stop.

8.7 Travel Performance

8.7.1 Control

(a) *Factors Affecting Vehicle Speed.* Vehicle speed may be affected by dynamic operating characteristics of the vehicle system operating area including but not limited to the following:

- (1) floor conditions
- (2) load stability and retention
- (3) personnel access
- (4) environmental conditions
- (5) emergency devices
- (6) intended path

(b) *Acceleration.* The maximum acceleration rate should be commensurate with requirements for load stability during normal operation.

(c) *Deceleration*

(1) For normal operation, including for a safety stop, the deceleration rate should be commensurate with requirements for load stability.

(2) For emergency operation, the maximum deceleration rate shall be commensurate with emergency stop dynamic criteria including the requirements for load stability and retention. (see Section II, para. 4.3.1).

(d) *Monitoring.* Loss of speed control shall require an emergency stop.

8.7.2 Steering

Steering characteristics shall not degrade vehicle dynamic stability.

8.7.3 Ramps

(a) *Definition.* A variation in floor grade in excess of 3% and of a length where rating data variance is required shall constitute a ramp. See para. 8.18.1(a).

(b) *Speed Control.* Means shall be provided to control vehicle speed on ramps. Vehicle travel speed on ramps shall be agreed to by the system supplier and user as part of system parameters. Vehicles rated for ramp operation shall have provisions for starting and stopping on ramps.

(c) *Braking.* Controlled braking means shall be provided on vehicles which are designated for automatic ramp operation. Emergency braking performance shall be the same as for level horizontal operation. See para. 8.8.1.

8.7.4 Stability

(a) For vehicles with lift more than 300 mm, the applicable stability requirements of ANSI/ITSDF B56.1 shall apply. Design stability is the measure of a vehicle's resistance to overturning under rigidly controlled static conditions that include consideration for dynamic factors encountered in normal application and operation. Factors that may influence stability include weight, weight distribution, wheelbase, wheel tread, method of suspension, truck speed and turning radius, and tire and mast deflection under load.

(b) For vehicles with lift of 300 mm or less, the stability requirements of ANSI B56.8 shall apply.

8.8 Braking System and Functions

8.8.1 Braking System. The vehicle shall be equipped with a braking system which:

- (a) operates on interruption of power supply;
- (b) stops the vehicle within the operating range of the supplied object detection device(s) (see para 8.11.1) taking into account load, speed, friction, gradient and wear;
- (c) maintains the vehicle and its maximum allowable load stationary on the maximum operational gradient specified by the manufacturer;
- (d) operates on loss of critical control functions (see para 8.10.2).

8.8.2 Braking Functions

Vehicles shall have the following braking functions. Multiple functions may be provided by a single braking means.

(a) *Emergency Brake.* Emergency braking shall be provided for all vehicles. The emergency brake shall be mechanically set and require power or force from a source external to the brake to release. During automatic operations, this brake may be automatically actuated and de-actuated (see Section II, para. 4.3.1).

(b) *Parking Brake.* A parking brake, which may be a part of or include the service brake or emergency brake, shall be provided. When a vehicle is stopped, this brake shall be applied to prevent inadvertent movement of the stationary vehicle.

(c) *Service Brake.* A service brake, which may be a part of or include the parking brake or emergency brake, shall be provided. During manual operation, this brake is used for slowing or stopping the vehicle.

8.8.3 Controlled braking may be provided. Controlled braking is a means for an orderly slowing or stopping of the vehicle. This may be accomplished by electrical or mechanical means.

8.9 Warning Devices

8.9.1 Prior to initiation of vehicle movement or remote reactivation from a sleep or inactive condition, a warning device (on or off the vehicle) shall be activated, to be either audible, visual, or a combination thereof, indicating the imminent movement of the vehicle under automatic control. The warning light(s), such as strobe or flashing, shall be readily visible.

8.9.2 Vehicles shall provide a warning indication, either audible, visual, or a combination thereof, during all vehicle motion (see Section II, para 7.2.1 (e)).

8.9.3 Vehicles in motion shall provide a warning indication distinctive from the indication of para. 8.9.2 prior to travel in reversing, traversing, or pivoting direction.

8.9.4 An indication shall be provided to alert personnel of vehicle malfunction or safety device activation including the following:

- (a) loss of path reference or deviation from the intended guidepath
- (b) loss of speed control
- (c) other control system malfunctions that require intervention by a qualified operator

8.9.5 An indication should be provided for all vehicles capable of automatic operation to identify low battery condition when automatic routing to battery charging is not provided.

8.10 Vehicle Emergency Controls and Devices

8.10.1 Vehicle emergency controls and devices are those which automatically and rapidly stop propulsion, prohibit automatic restart, stop moving components, and apply the emergency braking. After detection of an emergency condition, emergency controls shall activate an emergency stop. Manual intervention by authorized and trained personnel at the scene of the emergency stop is required to return to normal operating conditions after verification that the vehicle can be restarted safely. The emergency stop function shall not be applied as a substitute for safeguarding measures and other safety functions but should be designed for use as a complementary protective measure. The emergency stop function shall not impair the effectiveness of protective devices or of devices with other safety functions.

The emergency stop function shall be designed that, after actuation of the emergency stop actuator, hazardous movements and operations of the machine are stopped in an appropriate manner, without creating additional hazards and without any further intervention by any person. An appropriate manner can include:

- (a) choice of an optimal deceleration rate;
- (b) selection of the stop category (e.g., immediate removal of power to the machine actuators, or mechanical disconnects (declutching) between the hazardous elements and their machine actuators and if necessary, braking; and
- (c) employment of a predetermined shutdown sequence.

The emergency stop function shall be so designed that a decision to use the emergency stop device does not require any person to consider the resultant effects.

8.10.2 Mandatory emergency control functions and devices shall include the following:

- (a) emergency stop switches (e.g., red mushroom), located on or off the vehicle and accessible to personnel
- (b) detection of loss of speed control
- (c) detection of unplanned loss of guide path reference or intended path
- (d) processor monitor (watchdog timer), if a processor is used
- (e) motive power interrupt,
- (f) failure detection of power supplies/sources that are critical to vehicle safety aspects

The failure of any of these devices or detection of these conditions shall bring the vehicle to an emergency stop, taking into consideration the requirements for load stability and retention.

8.11 Object Detection Devices and Controls

8.11.1 Object Detection Devices. A sensing device or combination of devices shall be supplied to prevent contact of the vehicle structure and installed equipment with people or objects appearing in the path of the vehicle in the main direction of travel.

8.11.1.1 Bumpers. If used as an object sensing device, a bumper shall be fail-safe in its operation and mounting and shall not exert a force greater than 134 N applied parallel to the floor and opposing the direction of travel with respect to the bumper. Bumper activation shall cause a safety stop within the collapsible range of the bumper (i.e., before vehicle structure contact).

8.11.1.2 Noncontact Sensing Devices. If used as the primary sensing device, such noncontact sensing device(s) shall be fail-safe in their operation and mounting. In the main direction of travel at a distance no less than the leading edge of the sensing field, actuation of the sensing devices shall cause the vehicle to stop prior to contact between the vehicle structure and the people or objects. (see para. 4.3.1)

8.11.1.2.1 Test Pieces. Test pieces shall be detected at 0%, 50% and 100% of vehicle speed in the main direction of travel and be positioned to be within the contour area of the vehicle (including onboard payload, equipment, towed trailer and/or trailer payload) as depicted in Fig. 1. Test piece surfaces must be covered as follows:

(19)

If optical sensors are used as object or person detection devices, the cylindrical test pieces must have an external surface reflectance of 6% or less and optical density of 1.22 (e.g., black) or less and the flat test piece must be highly reflective, polished metal surface of at least 88% reflectivity. If ultrasonic (sonar) sensors are used as object or person detection devices, flat test pieces must have a highly reflective surface. Note that the following test pieces also apply:

- (a) a test piece with a diameter of 200 mm and a length of 600 mm lying on and at 0° and 45° to the path of the vehicle, at a range equivalent to the vehicle safe stopping distance and positioned at the left-most, right-most and center of the vehicle path,
- (b) a test piece with a diameter of 70 mm and a height of 400 mm set vertically at a range equivalent to the vehicle safe stopping distance and positioned at the left-most, right-most and center of the vehicle path,
- (c) a test piece with a flat surface measuring 500 mm square set vertically, and at test angles of 0° and 45° perpendicular to the path of the vehicle, with closest point of the test piece at a range equivalent to the vehicle safe stopping distance and positioned at the left-most, right-most and center of the vehicle path.

8.11.1.3 Additional Object Detection Devices. Additional person or object detection devices may be provided at the request of the user and/or as required by the installation criteria.

8.11.1.4 Restricted areas and/or Manual Mode. Object detection devices are not required or may be deactivated when a vehicle is working in a restricted area or in the manual mode of operation.

8.11.1.5 In directions of travel where vehicles are not able to comply with para 8.11.1 (e.g., vehicles with fork arms, pivoting vehicles, or crabbing vehicles), the fastest moving part of the vehicle and its intended load shall not exceed a speed of 0.3 m/s, and a distinctive acoustic and visual warning signal shall be generated.

- (19) **8.11.2 Hazard Zones and Restricted Areas.** As stated in Paragraph 4.7.4, a minimum guidepath clearance (see glossary) of 0.5 m (19.7 inches) shall be maintained on both sides of the guidepath or on one side of the guidepath if the guidepath clearance on the other side is 0.1m (3.94 inches) or less to a continuous closed fixed structure (e.g. a wall). Maximum permitted vehicle speed and the use of object detection shall be in accordance with Table 1. All other areas shall be designated hazard zones or restricted areas by the user and system supplier and marked accordingly by the user using suitable signs or floor markings. (See para 4.7.4.1) Confusion with other markings and signs shall be avoided.
- 8.11.2.1** Before the vehicle enters such areas, speed shall be reduced and an audible warning shall be activated.
- (19) **8.11.2.1.1** In hazard zones (see glossary) the maximum travel speed shall be limited to 1.2 m/sec.
- (19) **8.11.2.1.2** In restricted areas (see glossary) the maximum travel speed shall be limited to 0.3 m/sec. The user and system supplier shall agree on appropriate protection measures for restricted areas. If an emergency stop device can be fitted, it shall be located on the vehicle within a 600 mm reach of the operator. In cases where the emergency stop device cannot be reached (e.g., a forked vehicle traveling in reverse for load deposit) user personnel shall be subject to verifiable training (see Section II, para 4.7.4.2)
- (19) **8.11.2.1.3** In VNA restricted areas (see glossary) the maximum travel speed shall be limited by sensing device and stopping distance as defined in 8.11.1. The user and system supplier shall agree on appropriate protection measures for VNA restricted areas. User personnel shall be subject to verifiable training (see Section II, para 4.7.4.2). VNA restricted areas shall be designated by the user and system supplier and marked accordingly by the user using suitable signs and/or floor markings (see para 4.7.4.1). Confusion with other markings and signs shall be avoided.

(19)

Table 1 Summary of Operating Speeds and Requirements in Hazard Zones and Restricted Areas

Case	Clearance 1 per 4.7.4 ¹	Clearance 2 per 4.7.4 ²	Is there an object detector per 8.11.1?	Are there E- stops within 600mm per 8.11.2.1.2?	Is there an escape route available? ³	Verifiable training Req'd	Max vehicle speed permitted	Resultant zone classification
A	≥0.5m	≥0.5m	Yes	N/A	N/A	No	Full ³	Non-Restricted
B	≥0.5m	<0.5, >0.1m	Yes	N/A	N/A	Yes	1.2m/s ⁵	Hazard
C	≥.5m	≤0.1m	Yes	N/A	N/A	No	Full ⁴	Non-Restricted
D	<0.5m	<0.5m	Yes	N/A	Yes	Yes	1.2m/s ⁵	Hazard
E	N/A	N/A	No	N/A	Yes	Yes	0.3m/s	Restricted
F	N/A	N/A	No	Yes	No	Yes	0.3m/s	Restricted
G	N/A	N/A	No	No	No	Yes	0.3m/s	Restricted
H	<0.5m	<0.5m	Yes	N/A	No	Yes	0.3m/s	Restricted
I	<0.5m	<0.5m	Yes	N/A ⁷	No	Yes	Full ⁶	VNA Restricted

Notes:

1) Clearance 1: Clearance available between adjacent fixed structures along the path or objects intentionally positioned in a designated location along one side of the path and the rigid parts of the truck, load and trailers if towed.

2) Clearance 2: Clearance available between adjacent fixed structures along the other side of the path or objects intentionally positioned in a designated location along the path and the rigid parts of the truck, load and trailers if towed.

3) A clearance greater or equal to 0.5m wide by 2.1m high from the walking plane, provides an escape route. Where clearances are less than 0.5m wide by 2.1m high from the walking plane, escape routes are required. Escape route are routes as intended by building codes that have unobstructed space of sufficient size (at least 0.5m wide by 2.1m high) for a person to exit. Examples are open ends of aisle or side corridor or intersecting aisle.

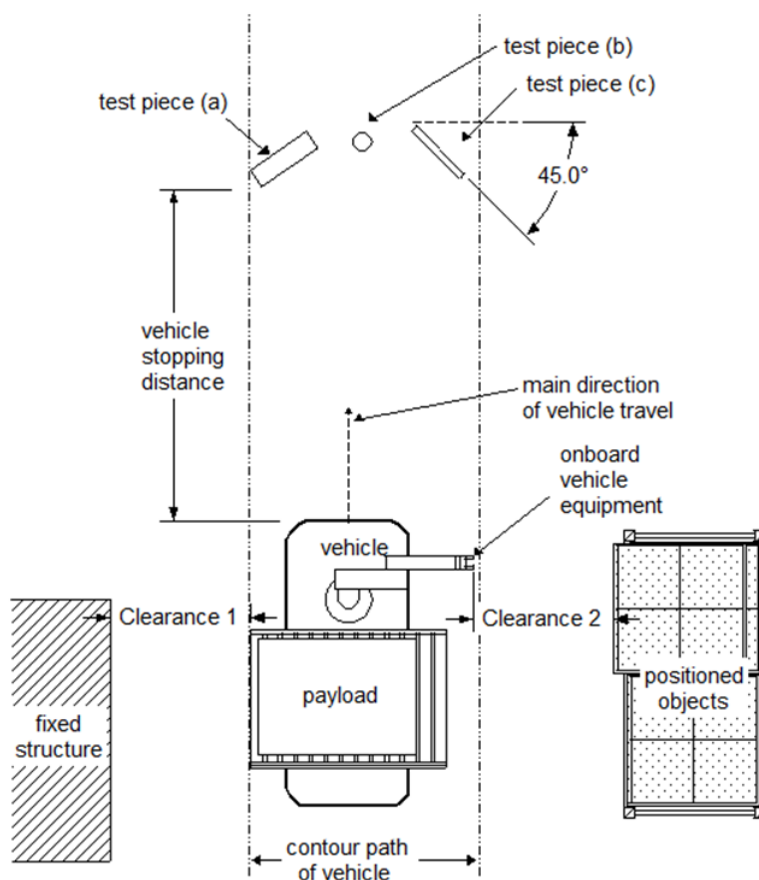
4) In this case, full speed with a non-restricted classification is allowed since: a person cannot fit within the narrow space between the truck and a continuous fixed closed structure without being detected and can escape via the 0.5 m clearance side.

5) Limited speed is defined in paragraph 8.11.2.1 as no more than 1.2 m/sec, (which is less than normal walking speed 1.56 m/s, per ANSI/ITSDF B56.1a-2018 5.3.20(i)).

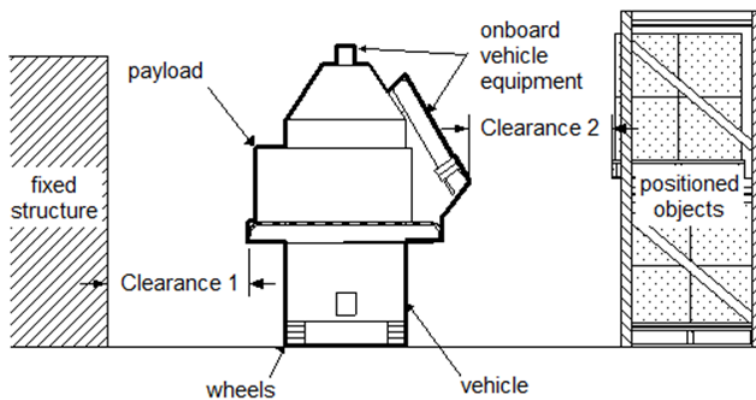
6) Full speed shall be defined with the requirements in 8.11.1.

7) Since a VNA AGV may travel faster than normal walking speed (1.56 m/s, per ANSI/ITSDF B56.1a-2018 5.3.20(i)), whether there is an escape route or not, is not applicable.

N/A = Not applicable



Top view of vehicle, vehicle path and standard test pieces, fixed structure, and positioned objects along the path.



Rear view of clearances (see Table 1) and vehicle contour (bold outline) with overhanging payload, and onboard equipment. Contour could also include a trailer and/or trailer payload (not shown).

(19)

Fig.1 Position of Test Pieces

8.11.3 Object Detection Control

8.11.3.1 Control Actuation. When actuated, object detection devices cause a slowing or safety stop of the vehicle. The vehicle action following a safety stop may be reinitiated automatically after a minimum delay of 2 seconds if and when the device or combination of devices no longer detect an object or obstruction to the vehicle and its intended load in the main direction of travel.

8.11.3.1.1 Object Detection. Specific sizes, shapes and reflectivity of the detected object(s) and area of coverage need to be defined and agreed upon between the system supplier and user if other than that specified in para. 8.11.1.2.1

8.12 Vehicle Nonemergency Controls and Devices

8.12.1 Subsystem Monitor. Optional monitors may be provided, such as automatic battery condition, load sensing, location of vehicle, belt failure, load interface locations, etc.

8.12.2 Controlled Stop Switch(es). A switch(es) that, when activated, will provide controlled stopping may be provided on the vehicle in a readily accessible location.

8.12.3 Manual Operator Controls. When operator controls are in use during manual or semi-automatic operation, automatic operation of functions under the operator's control shall be deactivated. The operator shall be responsible for the allowable functions when the vehicle is under his/her control. The operating speed, direction, or heading of vehicles manually operated with a pendant or equivalent control shall require continuous operator activation of the enabling device(s).

8.13 Control Disconnect

8.13.1 A manually operated switch (may be key-type) to disconnect all control circuits shall be provided.

8.13.2 In any mode of operation, a readily accessible means convenient to personnel shall be provided to quickly disconnect the battery power circuit in the event of an emergency.

8.14 Operational Modes

8.14.1 Automatic. The case when no operator intervention is required and all the functions of the vehicle(s) are directed by and under the control of programmed logic.

8.14.2 Semiautomatic (Optional). The case when, at a minimum, the intended path or direction of a vehicle and its speed are actuated and controlled by a person, with all other functions (e.g., load handling) under automatic control. Continuous operator activation of an enabling device(s) shall be required.

8.14.3 Manual. The case when complete vehicle operation is under control of a local operator either onboard the vehicle or by way of an attached or remote means. Continuous operator activation of a vehicle enabling device(s) shall be required. Safety devices required for automatic or semiautomatic operation may be overridden in manual mode. In manual modes the operator is fully responsible for the safety of the vehicle and the immediate surroundings.

8.14.4 Maintenance (Optional). A diagnostic or service mode where safety device overrides are permissible.

8.15 Manual Operation

8.15.1 Manual controls shall be provided in accordance with ANSI/ITSDF B56.1, ANSI/ITSDF B56.8, ANSI/ITSDF B56.9, or other safety standards, as applicable.

8.15.2 Special manual controls (e.g. pendant) shall be designed and marked such that the authorized operator can anticipate the resultant movement(s).

8.16 Protection From Moving Parts

Protection shall be provided to reduce foreseeable risk of personnel injury from moving parts (including wheels)

8.17 Load Handling Devices

8.17.1 Each vehicle-powered load handling device shall have emergency stop switch(es) on the vehicle accessible to operators, which can be the same as the vehicle emergency stop switches.

8.17.2 When the load handling device is not in a position designated as safe for transport, the vehicle load handling devices shall have an appropriate interlock to restrict vehicle movement to that required for safe positioning.

8.17.3 Powered load handling devices shall have an interlock when used in conjunction with powered load handling stands or devices external to the vehicle. Proper vehicle alignment and confirming signal shall be required prior to activation of load transfer mechanism(s). This interlock shall be capable of inhibiting movement of both the vehicle and the fixed equipment, when activated.

8.18 Signs

8.18.1 All vehicle signs shall be durable. An appropriate symbol may be used in lieu thereof.

(a) Vehicles designed for ramp operation shall be labeled MAXIMUM GRADE CAPABILITY = ____%, on the vehicle in letters at least 38 mm high.

(b) Vehicles capable of fully automatic operation shall have a label clearly visible that states, CAUTION: AUTOMATIC VEHICLE, in letters at least 38 mm high.

(c) Vehicles not designed with specific personnel compartments or platforms incorporating appropriate safety protection shall be labeled NO RIDING. Vehicles with specific personnel compartments or platforms incorporating appropriate safety protection shall be labeled UNAUTHORIZED RIDING PROHIBITED. The label shall be visible from at least two opposing sides of the vehicle using letters at least 38 mm high.

(d) Vehicles with a nominal voltage of 48 V or more that are designed for opportunity charging (see para. 8.18.3) should contain a sign, CAUTION: ____ VOLTS.

(e) Pendant controls should be labeled AUTHORIZED OPERATOR ONLY.

(f) Vehicles should be marked to indicate lift points, if applicable.

8.18.2 Vehicle base color and markings shall render the vehicle highly visible in the user's specified environment. Compliance with ANSI/NFPA 505 shall be required.

8.19 Changing and Charging of Batteries

8.19.1 Battery types and charging systems supplied or specified by the vehicle manufacturer (e.g., opportunity charging) but not referenced in ANSI/NFPA 505 shall have safe operating and charging instructions supplied by the vehicle manufacturer.

8.19.2 The battery compartment shall be designed in accordance with ANSI/UL 583. Battery arrangement shall allow venting to prevent accumulation of fumes.

8.19.3 Batteries for use in electric vehicles shall have the battery weight legibly stamped on the battery tray near the lifting means as follows: SERVICE WEIGHT ____ lb (kg). Where multiple batteries are used in a liftout tray with total combined service weight of batteries and tray exceeding 45 kg, the maximum combined weight of the batteries and tray shall be legibly stamped on the battery tray near the lifting means with the following information: SERVICE WEIGHT ____ lb (kg).

8.19.4 When opportunity or automatic charging is specified, the following shall also apply:

- (a) a recommended preventative maintenance program outlining routine service checks and appropriate procedures.
- (b) diagnostic check procedures. This shall be in the form of a troubleshooting guide that follows check procedures to provide recommended repair instructions.
- (c) procedures for repair of the equipment.
- (d) other pertinent information to operate and maintain reliability of all the system equipment.
- (e) the sequence of operations for all equipment and electronics.

8.20 Documentation

A manufacturer supplied vehicle maintenance manual shall be provided to the user which will describe at least the following:

- (a) a recommended preventative maintenance program outlining routine service checks and appropriate procedures,
- (b) diagnostic check procedures. This shall be in the form of a troubleshooting guide that follows check procedures to provide recommended repair instructions,
- (c) procedures for repair of the equipment,
- (d) other pertinent information to operate and maintain reliability of all the system equipment,
- (e) the sequence of operations for all equipment and electronics.

Part IV

Automated Functions of Manned Industrial Vehicles

9 SYSTEM SUPPLIER, MANUFACTURER, AND USER PRACTICES

9.1 Introduction

9.1.1 Part IV contains safety standards applicable to manufacturer and user practices. The user shall understand that when functions on manned industrial vehicles are automated, the operation of the vehicle is changed and it may result in modified performance characteristics, maintenance procedures, and additional safety precautions.

9.1.2 Before putting an industrial vehicle system into service, the user shall be responsible for all factors affecting the operation and maintenance, as referenced in Part II of this Standard.

9.1.3 Industrial vehicles can cause injury or damage if improperly used or maintained.

9.1.4 The addition of any automatic function to a manned industrial vehicle requires the evaluation of the impact of the automation on all other functions. It may be necessary to automate other functions to some degree. The basic functions covered by this Standard are:

- (a) steering (guidance)
- (b) travel
- (c) control and sensing
- (d) lifting/load manipulation

9.1.5 Automated functions shall comply with Part IV of this Standard. Manual functions shall comply with the applicable vehicle standard.

9.2 General Safety Practices

9.2.1 Operator Responsibility. Safe operation is the responsibility of the operator. When operator controls are in use, automatic operation of functions under the operator's control shall be deactivated. All operating speeds or motions of manually operated functions shall be such that manual control can be maintained.

9.2.2 Modification, Nameplates, Markings, and Capacity

(a) Modifications and/or additions of hardware or software which affect rated capacity, safe operation, or any emergency control or device shall not be performed by the user without the system supplier's verifiable approval. Where such authorization is granted, capacity, operation, and maintenance instruction (plates, tags, or decals) shall be changed accordingly.

(b) A nameplate shall be provided to designate compliance with the mandatory requirements of Part IV of this Standard.

(c) When an automated function is provided, all affected nameplate data (para. 8.5) shall be inscribed on a nameplate.

(d) The user shall see that all required nameplates and caution and instruction markings are in place and legible.

(e) The user shall consider that changes in load(s), load position(s) or dimension(s), coupling type(s) or position(s), and floor surface condition(s) or battery weights may affect rated capacities and safe operation. Only stable or safely arranged loads shall be handled.

(f) The user shall define and be responsible for load stability and retention.

9.2.3 Warnings. Vehicles shall be equipped with an automatic device(s), either audible, visible, or a combination thereof, which shall function during all vehicle motion not under control of the operator.

9.2.4 Safety Device Activation. An indication, either audible, visual, or a combination thereof, shall be provided to alert personnel of safety device activation for automated functions. (See paras. 8.10 and 8.11.)

9.2.5 Protection From Moving Parts. The addition of an automatic function(s) shall provide the same protection from moving parts as specified by the applicable vehicle standard.

9.2.6 Special Manual Controls. Special manual controls for automated functions (e.g., pendant) shall be such that the authorized operator can anticipate the resultant movement(s).

9.2.7 Multivehicle Systems. The manufacturer of the fully automated vehicles and the user shall consider the potential hazards of mixed vehicle traffic, where fully automated vehicles interface in a system where manned and/or partially automated manned vehicles are also operating. Some examples of these areas are, but not limited to, aisles, passageways, intersections, and doorways.

9.3 Control and Sensing

Additional control and sensing devices may be provided. When provided, the control and sensing devices shall conform to paras. 8.10 and 8.11, where applicable.

9.4 Steering (Guidance)

Automatic steering functions may be provided. When provided, there shall be no combining of automatic and manual steering modes. Where both modes are provided, there shall be means for the operator to select one mode or the other (see paras. 8.6 and 8.7.2).

9.5 Travel

Automatic travel function(s) may be provided. When provided, they shall not be shared but may be overridden by the operator or limited by the automatic mode (see paras. 8.7.1, 8.7.3, and 8.8).

9.6 Lifting/Load Manipulation

Automatic lifting/load manipulation functions may be provided. When automated, they shall conform to para. 8.16. Characteristics of the automated function may require additional sensing.

9.7 Documentation

A manufacturer supplied maintenance manual shall be provided to the user which will describe at least the following:

- (a) the sequence of operations.
- (b) a recommended preventive maintenance program outlining routine service checks and appropriate procedures.
- (c) diagnostic check procedures. This shall be in the form of a troubleshooting guide that follows check procedures to provide recommended repair instructions.
- (d) procedures for repair of equipment.
- (e) other pertinent information to operate and maintain reliability of all the system equipment.

MANDATORY APPENDIX I REFERENCES

The following are safety standards and codes (unless otherwise noted) referenced within this Standard. It is the intent of this Standard to refer to the standards and codes listed below in their latest edition when they are referenced within the Standard.

ANSI/ITSDF B56.1a-2018, Low Lift and High Lift Trucks
ANSI/ITSDF B56.8-2011, Personnel and Burden Carriers
ANSI/ITSDF B56.9-2011, Operator Controlled Industrial Tow Tractors

Publisher:
The Industrial Truck Standards Development Foundation (ITSDF),
1750 K St NW, Suite 460
Washington, DC 20006

ANSI/NFPA 505-2013, Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Maintenance, and Operation

Publisher:
National Fire Protection Association (NFPA),
1 Batterymarch Park, Quincy, MA 02169-7471

ANSI/UL 558-2008 Standard for Safety for Internal Combustion-Engine-Powered Industrial Trucks
ANSI/UL 583-2007 Standard for Safety for Electric-Battery-Powered Industrial Trucks

Publisher:
Underwriters Laboratories, Inc. (UL),
333 Pfingsten Road Northbrook, IL 60062-2096

The following are related documents:

ANSI/IES RP7-1990, Practice for Industrial Lighting (not a safety standard)
ANSI Z535.1-2006, Safety Color Code
ANSI Z535.2-2007, Environmental and Facility Safety Signs
ANSI Z535.3-2007, Criteria for Safety Symbols
ANSI Z535.4-2007, Product Safety Signs and Labels

Publisher:
American National Standards Institute, Inc. (ANSI),
25 West 43rd Street, New York, NY 10036

ANSI/NFPA 30-2007, Flammable and Combustible Liquids Code
ANSI/NFPA 58-2008, Storage and Handling of Liquefied Petroleum Gases

Publisher:
National Fire Protection Association (NFPA),
1 Batterymarch Park, Quincy, MA 02169-7471

MANDATORY APPENDIX II

Glossary of Commonly Used Words and Phrases

aisle, guidepath clearance: the envelope of space required for the vehicle, including mounted equipment, and its intended load to move automatically without contacting fixed obstructions.

alteration: any change to equipment, including its parts, components, and/or subsystems, other than maintenance, repair or replacement.

ampere-hour capacity: the ampere-hours that a storage battery can deliver under specified conditions such as temperature, rate of discharge, and final voltage.

authorized person: a trained person who has been given responsibility to work within a defined area and/or to operate or maintain the vehicle system.

automatic operation: the case when no operator intervention is required and all the functions of the vehicle(s) are directed by and under the control of programmed logic.

sleep (optional): a condition, in automatic operation, in which all vehicle power is shut off except for the ability to receive a “wake-up” signal.

battery charging, automatic: charging achieved through the automatic connection of the charging equipment to the battery while the battery is in the vehicle.

battery charging, central: battery charging in a designated area while the vehicle is not in service.

battery charging, opportunity: charging the battery while the vehicle is in service.

brake, emergency: a device(s) to stop the vehicle (from rated speed with a rated load) between the object sensed and contact with the vehicle frame or load.

brake, parking: a device(s) to prevent inadvertent moving of the stationary vehicle.

brake, service: a device(s) for slowing or stopping the vehicle during manned operation.

braking: any controlled or emergency means to slow or stop the vehicle.

braking, controlled: a means for slowing or stopping the vehicle.

bumper: a mechanically actuated device which, when depressed, causes the vehicle to stop.

(19) *designated area:* an area along the vehicle guidepath meant for placement of objects (e.g. loads).

deviation: a measurement derived from the vehicle control logic and guidance reference information that enables the vehicle to know whether it is wandering off the current intended path such that when specified deviation tolerances are exceeded appropriate action can be taken. (See *intended path* and *guidance reference*)

drawbar pull, breakaway: the maximum pull in pounds (Newtons) a vehicle will develop statically on a level floor having the prescribed coefficient of friction, when moving a load at a uniform rate.

drawbar pull, maximum: the maximum pull in pounds (Newtons) a tractor or tow vehicle will develop on a level floor having the prescribed coefficient of friction, when moving a load at a uniform rate.

emergency stop: (also known as E-stop) one that occurs for unprogrammed events detected through sensors or an emergency button on the vehicle.

fail-safe: a design in which no single failure can cause an unsafe condition.

guided industrial vehicle system: see *vehicle system*, *guided industrial*.

guided tow vehicle: see *vehicle*, *guided tow*.

guidepath: an intended path for guided industrial vehicle use with automatic guidance.

- (19) *guidepath clearance*: a ground area up to a height of 2.1 m between adjacent fixed structures along the vehicle guidepath or objects intentionally positioned in a designated area along the vehicle guidepath and the rigid parts of the vehicle, the load, and trailers if towed.

guidepath clearance aisle: see *aisle*, *guidepath clearance*.

- (19) *hazard zone*: an area of inadequate guidepath clearance

- (19) *hazardous location*: an area as described in NFPA 505 and NFPA 70 which presents a potential hazard due to the presence of combustible or flammable materials, gases, or vapors.

intended path: the heading of a vehicle at a given instant in time dictated by the control logic, recognizing that the heading is a dynamic property and can change at any instant in time depending on conditions in the operating environment (e.g., the decision to allow a vehicle to pass another vehicle or to navigate around an obstacle). (See *deviation*, *guidance reference*, *external* and *guidance reference*, *internal*)

local operator: an operator within reach of the vehicle, its control, or safety devices.

main direction of travel: the forward movement of the vehicle, including turns, unless otherwise specified and agreed to by the user and system supplier.

manned industrial vehicle: a vehicle with an operator and/or other person on board associated with vehicle function.

manual operation: the case when complete vehicle operation is under control of a local operator either onboard the vehicle or by way of an attached or remote means. Continuous operator activation of a vehicle enabling device(s) shall be required. Safety devices required for automatic or semiautomatic operation may be overridden in manual mode.

manufacturer: A company or organization that provides the design of a vehicle(s) and related controls and causes the vehicle(s) to be produced from raw materials and/or other components. The manufacturer may also serve as the system supplier for a given application and therefore be responsible for the vehicle system to be installed and integrated into the environment where it will be operating (see also system supplier)

modification: see *alteration*.

non-contact sensing device: An acoustic device (e.g., sonar) or an optic device (e.g., photo eye or laser), configured with a properly defined forward, rear or side looking detection fields that cause the vehicle to slow down or stop when the leading edge of the detection field detects an obstacle in its path or when the detection field itself is infringed upon by an obstacle at any point within the detection field.

non-restricted area: area in which the guidepath is installed which is shared with personnel.

operating modes: the means provided that permit a vehicle to move and its functions to be controlled (See automatic operation, semi-automatic operation, and manual operation)

passenger: a person who rides the vehicle or a unit towed by the vehicle for transportation purposes. A passenger has no responsibilities or duties associated with any function of the vehicle in any mode of operation.

pendant control: a hand-held device for vehicle control.

processor monitor: a hardware device that ensures that the software program in the computer is being executed.

qualified person: a person who, by possession of a recognized degree or certificate of professional standing or by extensive knowledge, training, and experience, has successfully demonstrated the ability to solve or resolve problems relating to the subject matter and work.

rated capacity: the load, its position, and the vehicle speed, as established by the manufacturer, at which design performance can be expected.

rated load: the weight, envelope, and center of gravity, as established by the manufacturer, at which design performance can be expected.

rated speed: the speed, as established by the manufacturer, at which design performance can be expected.

(19) *restricted area:* an area of inadequate guidepath clearance with no escape route or an area of guidepath clearance which cannot be protected by object detection devices.

risk assessment: A comprehensive evaluation of the possible injury or damage to health in a hazardous situation in order to select appropriate safeguards.

safeguard: A barrier guard, device or safety procedure designed for the protection of personnel.

safeguarding: The act of providing personnel with protection from a hazard.

safety stop: A type of interruption of operation that allows an orderly cessation of motion for safeguarding purposes. This stop retains the program logic for troubleshooting purposes and to facilitate a restart.

semi-automatic operation: the case when, at a minimum, the intended path or direction of a vehicle and its speed are actuated and controlled by a person, with all other functions (e.g., load handling) under automatic control. Continuous operator activation of an enabling device(s) shall be required.

sleep (optional): a condition, in automatic operation, in which all vehicle power is shut off except for the ability to receive a "wake-up" signal

supplier: A company or organization that provides components used in the production of the vehicle or vehicle system.

system supplier: The term System Supplier refers to the entity with whom the user has contracted to provide a fully functioning system in accordance with the system design requirements and the standards contained herein. The System Supplier has the ultimate responsibility for documenting the system design requirements, providing the final system design, the installation and integration of the vehicle(s), and the overall performance of the system and vehicle(s) according to the provisions of this standard. The

System Supplier is also responsible for providing all system documentation, including all operation, training and maintenance manuals, as well as seeing that all vehicle name plate information is provided as specified in this standard. The System Supplier may or may not be a Manufacturer.

training, verifiable: planned training with a method statement jointly developed and conducted by the supplier and user acting as a team, including a means of documenting that specified learning objectives have been met and how the inevitable future change in user personnel shall be handled.

vehicle, guided tow: a vehicle which tows wheeled containers connected to, but separate from, the vehicle itself.

vehicle system, automatic guided: driverless, vehicle(s) and all components of an installation related to the vehicle(s) (e.g., guidepaths, controls, vehicle trailers, loads when on the vehicle or trailers, and other equipment when interfacing with these items) being capable of automatic operation.

verifiable approval: documentation from the vehicle manufacturer indicating approval of the proposed change to the vehicle.

- (19) *Very Narrow Aisle (VNA) restricted area:* an area defined by fixed continuous racking and clearances of less than 0.5 m on both sides. Unauthorized personnel are prohibited from entering the area.

watchdog timer: see *processor monitor*.

ANSI/ITSDF B56.5 INTERPRETATIONS

Replies to Technical Inquires March 2012 through July 2019

FOREWARD

This publication includes all of the written replies issued between the indicated dates by the Secretary, speaking for the ITSDF B56 Committee of Powered and Nonpowered Industrial Trucks, to inquiries concerning interpretations of technical aspects of ANSI/ITSDF B56.5 Guided Industrial Vehicles and Automated Functions of Manned Industrial Vehicles.

These replies are taken verbatim from the original letters except for a few typographical corrections and some minor editorial corrections made for the purpose of improved clarity. In some few instances, a review of the interpretation revealed a need for corrections of technical nature; in these cases a corrected interpretation follows immediately after the original reply.

These interpretations were prepared in accordance with the accredited ITSDF procedures. ITSDF procedures provide for reconsideration of these interpretations when and if additional information is available which the inquirer believes might affect the interpretation. Further, persons aggrieved by this interpretation may appeal to the cognizant ITSDF Committee or Subcommittee. ITSDF does not “approve,” “certify,” “rate,” or “endorse” any item, construction, proprietary device, or activity.

Interpretation: 5-17

Subject: ANSI/ITSDF B56.5-2012. Sections 4.7.2 and 5.1 Floor Marking

Date Issued: January 11, 2018

The following paragraphs in ANSI/ITSDF B56.5-2012 require floor space boundary markings.

4.7.2 In non-restricted areas, the floor space boundary required for the vehicle and its intended load and/or train shall be clearly marked, including the clearance necessary for turns and maneuvering.

5.1 (b) Permanent aisles, roadways, and passageways shall be marked by the user as a warning to personnel of existing or impending automatic guided industrial vehicle traffic and to indicate that these vehicles have the right of way.

Some autonomous vehicles can automatically reroute around obstacles temporarily located in the normal travel path. The new path opportunity includes the available space around the obstacle.

Question (1): Will signage posted in the facility stating that an automatic vehicle is in operation satisfy this requirement for floor space marking since the entire facility is the operating area?

Answer (1): If the intended path of an AGV is the entire floor surface of a facility, signs posted around a facility satisfy the requirements of 4.7.2 and 5.1 (b). Note that there are additional requirements that must be met including training of personnel, safeguarding of personnel, and possible speed reductions of an AGV in areas with inadequate clearances.

Question (2): Can a light projected forward on the floor in the direction of travel from the automatic guided industrial vehicle satisfy this requirement?

Answer (2): The means of marking floor space boundaries is not specified by ANSI/ITSDF B56.5-2012. Note that the boundaries to be marked are not just direction of travel, but also clearances on all sides of the vehicle and load including clearances for turns and maneuvering.

Interpretation: 5-18

Subject: ANSI/ITSDF B56.5-2012, Section 8.17.1 Load Handling Devices

Date Issued: January 4, 2018

The following paragraphs in ANSI/ITSDF B56.5-2012 refer to a load handling device.

8.17 Load Handling Devices

8.17.1 Each vehicle-powered load handling device shall have emergency stop switch(es) on the vehicle accessible to operators, which can be the same as the vehicle emergency stop switches.

8.17.2 When the load handling device is not in a position designated as safe for transport, the vehicle load handling devices shall have an appropriate interlock to restrict vehicle movement to that required for safe positioning.

8.17.3 Powered load handling devices shall have an interlock when used in conjunction with powered load handling stands or devices external to the vehicle. Proper vehicle alignment and confirming signal shall be required prior to activation of load transfer mechanism(s). This interlock shall be capable of inhibiting movement of both the vehicle and the fixed equipment, when activated.

Question (1): What is the definition of a “load handling device”?

Answer (1): ANSI/ITSDF B56.5-2012 does not provide a definition for “load handling device”. The intent of the wording is to describe requirements for a mechanism that provides any lifting, lowering, load transfer, and load manipulation (e.g. rotation, reach, tilting, clamping and towing).

Question (2): Do these paragraphs apply only to a “vehicle-powered load handling device” and, therefore, do not apply to an unpowered load handling device?

Answer (2): 8.17.1 applies to vehicle-powered load handling devices only. 8.17.2 applies to all load handling devices. 8.17.3 applies to all powered load handling devices.

Interpretation: 5-19

Subject: ANSI/ITSDF B56.5-2012 Section 4.7.4, 8.11.2 Hazardous Zones

Date Issued January 7, 2019

Question (1): Considering the following wording in ANSI/ITSDF B56.5-2012:

4.7.4 A minimum clearance of 0.5 m (19.7 inches) shall be maintained between obstructions and vehicles (including loads). All other areas having reduced clearance shall be considered hazard zones or restricted areas and be clearly marked by signs, stripes, lights, or other designations. (see Part III, para 8.11.2)

8.11.2 Hazardous Zones. Areas which cannot be protected by an object detection device(s), as well as areas of inadequate clearance in which vehicles operate, shall be designated hazard zones by the user and system supplier and marked accordingly by the user using suitable signs or preferably floor markings. (See para 4.7.4.1) Confusion with other markings and signs shall be avoided.

8.11.2.1 Areas of clearance of less than 0.5 m to a height of 2.1 m may be a risk to personnel. (see para 8.9.3) Before the vehicle enters such areas, speed shall be reduced and an audible warning shall be activated.

8.11.2.1.1 If there is an escape route for a pedestrian the maximum travel speed shall be limited to 0.3 m/s and the vehicle path shall be considered a hazard zone.

Is an area considered a hazard zone if 0.5 m can only be maintained on one side of the aisle? If a vehicle is heading down an aisle with walls on both sides where with one side up against a wall and the other side is maintaining the 0.5m clearance, does the vehicle have to slow down to 0.3 m/s?

What if more than 0.5m clearance is maintained on one side of the vehicle? If the vehicle is traveling parallel to a wall, and there is minimal clearance between the vehicle and the wall but a large amount of clearance on the other side of the vehicle, does the vehicle need to slow down to 0.3 m/s?

Answer (1): As the standard is currently written, if a vehicle was traveling along a wall with less than 0.5m clearance on any side and there is no escape route for a pedestrian in the vehicle path, it is considered a restricted area and the user and system supplier shall agree on appropriate protection measures for this situation (see 8.11.2.1.2). If there is an escape route for a pedestrian, it is considered a hazard zone and the speed shall be limited to 0.3 m/s (see 8.11.2.1).

The same applies even if only one side of a vehicle has less than 0.5m clearance and the other side has more than 0.5m clearance.